BULLETIN

OF THE INSTITUTE OF METALS

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INSTITUTE NEWS

New Honorary Members

The Council has recently elected to Honorary Membership of the Institute:

Sir JOHN COCKCROFT, O.M., K.C.B., M.A., D.Sc., F.R.S., Member for Research, U.K. Atomic Energy Authority.

Sir CHRISTOPHER HINTON, K.B.E., M.A., D.Eng., F.R.S., Chairman of the Central Electricity Generating Board.

Professor Dr. WERNER KÖSTER, Professor of Metallurgy at the Technische Hochschule, Stuttgart, and Director of the Max-Planck Institut für Metallforschung.

New Fellow

Professor Dr. A. VON ZEERLEDER has been made a Fellow of the Institute in recognition of his services for many years as Honorary Corresponding Member to the Council for Switzerland.

GOLDEN JUBILEE SPRING MEETING

The President and Lady Tedder receiving Major C. J. P. Ball (Past-President) at the Reception held at the Fishmongers' Hall on 29 April 1958.

Powder Metallurgy Joint Group

The next meeting of the Powder Metallurgy Joint Group will deal with "The Powder Metallurgy of Ceramic–Metal Materials". It will be held at Church House, Great Smith Street, London, S.W.1., on Tuesday and Wednesday, 16 and 17 December 1958. There will be an introductory lecture on the evening of the 16th, and the whole of the 17th will be devoted to the discussion of a number of specially invited papers which will be published in the *Journal* beforehand.

"The Abstracts Journal of Metallurgy"

With this issue members should receive a leaflet announcing *The Abstracts Journal of Metallurgy*, published by the Pergamon Press, Ltd., on behalf of the Board of Governors of *Acta Metallurgica*.

As the Institute of Metals is a co-operating society in this project, members may subscribe at the reduced rate of £3 10*s*. 0*d*. ($10.00) per annum. Members may likewise subscribe at a reduced rate to the English translation of *Fizika Metallov i Metallovedenie* which is also being published by the Pergamon Press, Ltd., on behalf of *Acta Metallurgica*. Subscription should *not* be sent to the Institute.

PERSONAL NOTES

Mr. S. E. Clotworthy, Managing Director of the Northern Aluminium Co., Ltd., has been elected President of the Aluminium Development Association for 1958–59.

Dr. R. F. Hanstock has joined the Research and Development Branch of the U.K. Atomic Energy Authority, Industrial Group, Culcheth, near Warrington.

Dr. N. P. Inglis, Research Director of Imperial Chemical Industries, Ltd., Metals Division, has been appointed Chairman of the Executive Committee of the Aluminium Development Association in succession to Mr. J. H. Mayes.

Dr. D. J. McPherson has been appointed Manager of the Metals Research Department at the Armour Research Foundation of the Illinois Institute of Technology.

Dr. R. F. Mehl, Head of the Department of Metallurgical Engineering at the Carnegie Institute of Technology, Pittsburgh, Pa., has been elected a member of the U.S. National Academy of Sciences.

Mr. N. D. G. Robertson, Jr., has been appointed Managing Director of The Non-Ferrous Die Casting Co., Ltd., in succession to his father.

Mr. T. M. Sabine has left the Atomic Energy Research Establishment, Harwell, and is now at the Research Establishment of the Australian Atomic Energy Commission, Sutherland, N.S.W.

Mr. Christopher Smith, Works Superintendent of James Booth and Co., Ltd., has been appointed a special director of the Company.

Mr. E. E. Spillett, Development Manager of The British Aluminium Co., Ltd., has been appointed Chairman of a committee recently set up by the Aluminium Development Association to study the applications of aluminium in chemical and nuclear engineering.

Dr. J. F. Thompson, Chairman of the International Nickel Company of Canada, Ltd., has been awarded the Gold Medal of the Institution of Mining and Metallurgy in recognition of his distinguished services to metallurgical science, research, and practice, with special reference to the nickel industry.

Death

The Editor regrets to announce the death of:

Mr. John Gray Buchanan on 22 April 1958, aged 88. He was a Director, and former Chairman, of William Jacks and Co., Ltd., iron, steel, and metal merchants, London.

OBITUARY

Dr. P. Herasymenko

Dr. Polykarp Herasymenko, Research Professor at New York University's College of Engineering, died suddenly on 6 April, of a coronary thrombosis. He was 57.

Dr. Herasymenko had been associated with New York University since 1952, conducting fundamental research into process metallurgy, titanium metallurgy, and thermodynamics. In the course of his career in Europe and the United States, he made important contributions to these fields, as well as to the ionic theory of steelmaking and the problems of hydrogen pick-up in liquid steel.

Born and educated in the Ukraine, Polykarp Herasymenko emigrated to Czechoslovakia in 1921 and received his doctorate from Charles University, Prague, in 1925. An International (Rockefeller) Research Foundation grant awarded in 1928 enabled him to carry out research in physical chemistry at King's College, London. In 1930 he became head of the metallurgical and physical-chemistry sections of the research laboratories of the Skoda works in Pilsen. He held this position until August 1945, when he emigrated to West Germany. From 1948 to 1951 he served as a research metallurgist on the staff of the United Steel Companies, Ltd., Sheffield.

LETTERS TO THE EDITOR

The Niobium–Hydrogen System

Sieverts first showed that the metal niobium is capable of absorbing hydrogen to compositions approaching the stoichiometric ratio NbH, and Brauer and Hermann [1] have used the X-ray-diffraction technique to determine the phases existing at room temperature in alloys of various compositions. They conclude that up to a composition $NbH_{0\cdot1}$ the process of absorption is one of solution in the body-centred cubic lattice of niobium; above this a hydride phase appears and increases in amount to a composition $NbH_{0\cdot7}$, after which the original niobium phase is no longer observed.

The hydride phase was shown by Brauer and Hermann to be a slightly deformed body-centred cubic lattice, derived from the niobium lattice by a small reduction of one of the angles of the cube, the side of the cell being 3–4% greater than that of the niobium cell. The new lattice is conveniently described in terms of an orthorhombic cell, the diagonals of the deformed face being used as two of the axes. An X-ray-

diffraction photograph from a specimen within the duplex field shows two patterns which at first sight are similar, the spacing between corresponding lines being in accordance with the 3% difference in cell size. The hydride lines in addition show fine structure corresponding to the departure from cubic symmetry.

We have made a qualitative X-ray-diffraction examination of the reactions between niobium and hydrogen at temperatures somewhat above room temperature, and have found that the following marked changes occur in the range 50°–250° C.:

(1) The single-phase alloy rich in hydrogen shows the orthorhombic structure at room temperature as evaluated by Brauer and Hermann. When the temperature is raised, the amount of distortion diminishes, so that from about 100° C. upwards the lattice is substantially cubic.

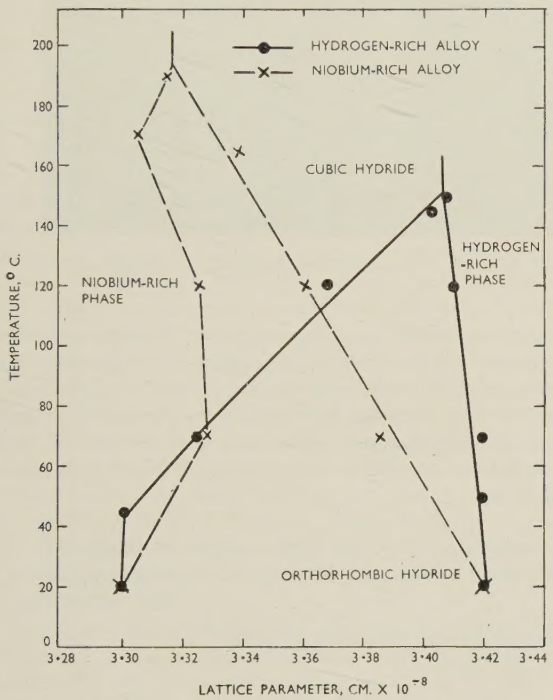

FIG. 1.—Variations of lattice parameters in two-phase field.

(2) Alloys in the two-phase field at room temperature show both structures, the respective parameters remaining the same across the field, and the relative intensities differing with composition, in accordance with normal thermodynamic criteria. The distortion of the hydride lattice diminishes as the temperature is raised, as with the single-phase alloy, and simultaneously changes in parameter occur. Whereas, however, the parameters of the phases in a two-phase field normally remain the same across the field at any one temperature, we find that our observations are determined by the particular alloy being examined, and not by the conditions at the boundaries of the region.

Thus for a two-phase alloy containing relatively little hydrogen, the parameter of the hydride phase diminishes steadily as the temperature is raised, while that of the niobium phase alters only slightly, so that the end product at a sufficiently high temperature is a single cubic lattice having a parameter only slightly different from that of the niobium phase. With a high hydrogen content the process is the converse of this, the hydride phase remaining almost unaltered and the parameter of the niobium phase increasing steadily until there is coincidence in a cubic lattice with parameter close to that of the hydride. Consequently at a given intermediate temperature the patterns from two such alloys do not show the same parameter values. The process of variation is illustrated in Fig. 1.

(3) Our experiments indicate, as a result of the above observations, that beyond a certain temperature (*ca.* 250° C.) there is a continuous body-centred cubic phase across the niobium–hydrogen system, the parameter increasing with increasing hydrogen content to a value 3–4% larger than that of pure niobium.

These results suggest that the region within which two phases exist is bounded by a closed loop, with a maximum in the neighbourhood of 250° C. In view of the abnormal variations in parameter that have been observed, it is proposed to pursue the X-ray-diffraction investigation, using direct counting methods in order to obtain more rapid quantitative estimations of line positions, shapes, and intensities, than is possible with photographic techniques.

During the course of this work, a number of X-ray photographs have been obtained from heavily cold-worked samples, and these show the short intense arcs which are typical of highly orientated material. It is found that when sufficient hydrogen is introduced into such samples to show hydride lines, the additional lines reproduce the orientations of the matrix. This relationship is in accordance with Brauer's analysis, and with the development of the hydride phase by deformation of the niobium lattice, rather than by the nucleation and growth of independent crystals. It also suggests that highly worked samples may serve more generally to demonstrate such relationships in ductile materials, when single crystals are not available for full analysis.

Acknowledgement—The work described above has been carried out as part of the General Research Programme of the National Physical Laboratory, and this note is published by permission of the Director of the Laboratory.

C. WAINWRIGHT

Metallurgy Division,
National Physical Laboratory,
Teddington, Middlesex.

REFERENCE

1. G. Brauer and R. Hermann, *Z. anorg. Chem.*, 1953, **274**, 11.

On the Nature of Polished Metal Surfaces ★

IT is still undecided whether a metal surface remains crystalline or becomes amorphous on polishing.[1] When such surfaces are examined by electron diffraction (reflection diffraction), the patterns usually show two diffuse haloes whose presence can be explained on the basis of either point of view. The following experiments were carried out to determine whether any conclusion regarding the nature of the surface could be arrived at.

A small thin glass plate was taken as providing an amorphous surface.[2] It was boiled in chromic acid solution, washed with distilled water and absolute alcohol, and dried. An electron

★ Since writing this note my attention has been drawn to the paper by L. E. Samuels (*J. Inst. Metals*, 1956–57, **85**, 177). The results reported in the present note seem to support his conclusion.

(reflection) diffraction photograph of the surface was taken in an R.C.A. electron microscope with a diffraction adapter and decharger. Diffuse reflections were obtained, which do not reproduce well. Next, on this glass, kept at room temperature, pure silver was deposited by evaporation at a pressure of 0·05 mm. for 20 sec. An electron-diffraction photograph was taken immediately afterwards (Fig. 1).

A piece of spectroscopically pure nickel was polished by a cloth buff rotating at a speed of 2000 r.p.m. for 15 min., using "Peerless" polishing compound. A reflection diffraction photograph was immediately taken (Fig. 2). Two diffuse haloes characteristic of such surfaces were obtained. The ratio of their radii is 0·56, and the calculated d values for these rings are 2·25 and 1·26 Å. As these are very close to the values obtained by Raether for nickel[3] this surface is assumed to be in the same state of polish as those used by Raether. The innermost ring is spurious.

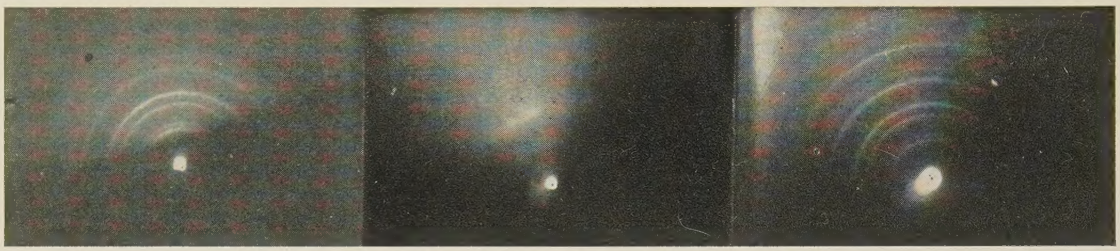

Fig. 1.—Silver deposited on glass. Fig. 2.—Polished nickel surface. Fig. 3.—Silver deposited on polished nickel.

Silver was then deposited on the nickel under conditions identical with those used in depositing the silver on glass and for the same time. The pattern, which was obtained immediately afterwards, is shown in Fig. 3.

Figs. 1 and 3 indicate that minute silver crystals having random orientation were formed on both glass and nickel surfaces. The pattern of silver on glass shows the normal powder reflection pattern. The pattern of silver on nickel shows the peculiarity that, in comparison with the (200) reflection, the (111) reflection has become stronger than it was in the case of silver on glass.

The observed increase in intensity of the (111) reflection of silver on nickel may be explained by assuming that additional (111) planes of silver on nickel have been formed. It is possible that during the process of polishing, slip of the nickel crystallites takes place, exposing slip planes, the (111) planes, of nickel. These slip planes will be distributed at random on the surface of polished nickel. When silver is deposited on nickel, epitaxial growth of minute silver crystals may take place, with $(111)_{Ag} \parallel (111)_{Ni}$ on these exposed planes. As the number of (111) planes of silver increases, because of the randomness of the orientation, the number of such planes lying at the correct angle to reflect the beam increases and the cumulative effect of the same set of planes in different crystallites increases. Thus the (111) and higher-order reflections have increased in intensity relative to other reflections. For these planes of silver to grow, (111) planes on the surface of polished nickel should exist. That is, the surface of polished nickel is micro-crystalline.

According to Beilby, a polished metal surface loses its crystalline structure and is transformed into an amorphous viscous or liquid material, in which the atomic arrangement is similar to that in a liquid. This material flows and covers the polished surface and is preserved. Essential points are: (1) alteration of structure, and (2) plastic flow of surface layers. Our conclusion is that during the process of polishing slip takes place and in that sense there is flow of material. But the structure is not altered to such an extent as to make the surface structurally amorphous, since exposed slip planes cannot then exist.

Acknowledgement—The author wishes to thank Mr. G. L. Malhotra for taking the electron-diffraction photographs.

A. K. Chatterji ★

National Physical Laboratory of India,
New Delhi.

REFERENCES

1. Z. G. Pinsker, "Electron Diffraction", p. 376. **1953**: London (Butterworths Scientific Publications).
2. G. I. Finch and H. Wilman, *Ergeb. exakt. Naturwiss.*, 1937, **16**, 424.
3. Z. G. Pinsker, *op. cit.*, pp. 363, 369.

Extension to Metallurgy Department at Newcastle-upon-Tyne

Extensions to the Metallurgy Department of King's College, Newcastle-upon-Tyne, were opened on 16 May by Mr. Clive Cookson, Chairman of the Consett Iron Co., Ltd. The new premises include lecture theatres, research laboratories, machine shop, and accommodation for the staff. The new extensions will enable the annual intake of students to be doubled and will provide improved facilities for research. The head of the Department is Professor A. Preece.

★ Present address: Central Building Research Institute, Roorkee, U.P., India.

THE METALLURGICAL ASPECTS OF SEMI-CONDUCTORS B17

A one-day Symposium on "Metallurgical Aspects of Semi-Conductors" was held under the auspices of the Metal Physics Committee at the College of Technology, Gosta Green, Birmingham, on 25 February 1958. Professor G. V. Raynor, M.A., D.Sc., occupied the chair, and there was a good attendance in spite of very adverse weather conditions.

The summary of proceedings given below has been kindly prepared by Dr. R. L. Bell.

Introduction

THE large attendance for a meeting at which just one aspect of the science of semi-conductors was to be discussed is indicative of the very great effort which has been made over the last ten years to study semi-conducting materials. The best known of these materials are the elements germanium and silicon. They are already familiar in the shape of rectifiers and transistors, but the semi-conductor compounds—for example indium antimonide and bismuth telluride, which find application in infra-red and refrigeration devices, respectively—are little known in the ordinary metallurgical laboratory. This is hardly surprising, for all these materials are essentially non-metallic in certain important physical properties. However, the metallurgist has been able to make valuable contributions in developing preparation techniques and in the understanding of certain structural features. Thus the purification of germanium by zone-refining, the growth of single crystals, and the study of imperfections in semi-conductor crystals all involve techniques which are essentially metallurgical. In return, there have been two kinds of benefit to metallurgical science: first, the highly developed purification and preparation techniques have been successfully applied to metals, and secondly, the experimental observation of dislocations in germanium and silicon has provided valuable evidence toward our understanding of the general problem of crystal plasticity.

The objects of the symposium organized by the Metal Physics Committee were twofold: first, to give workers in this specialized field a chance to discuss common problems, and secondly, to provide an opportunity for the specialist to meet the metallurgist concerned with more conventional, more metallic materials.

For the benefit of these latter, the Chairman gave a brief introductory review of the subject. The idea of electrical semi-conduction by means of electrons in the "conduction band" and "holes" in the "valency band" led to the question of impurity-dominated conduction and the main problem in semi-conductor technology, namely the necessity for extreme purity. The success of the zone-refining technique in producing germanium with less than one part in 10^9 of ionizable impurity provided a foundation stone for the transistor industry, but the difficulties associated with the purification of silicon, and the even more exacting requirement of perfect stoichiometric balance in compound semi-conductors, are problems of the present. Likewise, although there is a good deal of evidence to show the different effects of dislocations in semi-conductors, our understanding of the behaviour of these dislocations is incomplete and the control of their number and distribution is a problem only partly solved.

The Purification of Semi-Conducting Materials and the Growth of Single Crystals

There were two invited papers in this section, which occupied the morning session. The first, by Mr. J. WILSON (Standard Telecommunications Laboratories), described a new approach to the purification and growth of silicon crystals. The high reactivity of molten silicon and the unfavourable distribution coefficients of certain impurities limit the efficacy of the physical zone-refining method, so recourse has had to be made to a chemical approach. Silane gas is generated by the reaction:

$$LiAlH_4 + SiCl_4 = SiH_4 + LiCl + AlCl_3.$$

An advantage of this particular process is that non-volatile impurities are immediately separated. The few which are present in gaseous form are dealt with specifically, either by treatment of the reactants or of the resultant silane. For instance, boron, which forms volatile diborane, can be retained in the reaction vessel as non-volatile lithium borohydride if the lithium aluminium hydride is maintained in excess.

The pure silane is cracked on a hot silicon surface and eventually massive silicon boules are built up. From these boules single crystals are pulled direct, without any intermediate melting process. This procedure avoids the possibility of crucible contamination. A molten layer of constant volume is maintained at the top of the boule by a radio-frequency heater which couples directly into the silicon, and as the crystal is drawn from the surface of the melt in the normal Czochralski method, the boule is fed upwards to replenish the molten pool.

The purest crystals obtained have had resistivities in the 10^3 ohm-cm. range and minority carrier lifetimes of above 400 μ sec.

Doped crystals are conveniently produced by mixing appropriate quantities of diborane or phosphine with the silane gas before decomposition.

Mr. W. D. LAWSON (Royal Radar Establishment) then gave a general review of the methods used in the different stages leading to the production of single crystals of semi-conductor compounds. In the purification of the constituents one or more of the physical refining processes (filtration, distillation, and zone-refining) may be combined with a chemical method. Sometimes, when the chemical refining involves the production of an intermediate compound, it is convenient to use a physical refining method on the intermediate compound before it is decomposed.

The fusion of the elements and the zone-refining of the final semi-conductor compound can be quite straightforward when vapour pressures are low and when the maximum melting point occurs at the stoichiometric composition. Where large vapour pressures are encountered, special techniques are necessary. For example, zone-refining may be carried out under a controlled pressure of one constituent. Where stoichiometric difficulties arise, crystal growth by deposition from the vapour phase may be the only answer. Though this method of growing crystals is more difficult to control than melt techniques, there is the possibility that the crystals produced will have lower defect concentrations, for the growing crystal is virtually free of constraints and the temperature at which growth takes place is considerably

below the melting point. Mr. A. Prior has developed the method with particular reference to lead selenide. By controlling the vapour pressure of selenium, both *p*- and *n*-type crystals of desired carrier concentration may be produced.

In reply to a question from the chair, Mr. Lawson discussed the problem of mixed intermetallic compounds. Where the lattice parameters of two compounds are very similar, as is the case with cadmium telluride and mercury telluride, mixed crystals with low carrier concentrations may be obtained. Generally, however, mixtures have high carrier concentrations. This is probably associated with the strain in the lattice, for, in general, the parameters of the constituent compounds differ considerably.

The question of departures from perfect stoichiometry was raised. This, a very important problem, seems to remain the most difficult one.

Structural Defects and the Plastic Deformation of Semi-Conductor Crystals

The first of the four invited papers in the afternoon session, given by Dr. W. Bardsley (Royal Radar Establishment) and Dr. R. L. Bell (Imperial College, London), concerned the study of dislocations in germanium. In this, brief reference was made to the important electrical effects of dislocations which have been observed. These effects may be due either to the unpaired electrons at the bottom of dislocation half-planes or to the segregation of impurities to these sites. In these studies the number and location of the dislocations are inferred from the action of selective etches in producing pits. Workers at the Bell Telephone Laboratories have established, in two specific instances at least, that the pits produced by the etch "CP4" locate the emergence at the surface of unit edge dislocations. Using this etch, the density of dislocations in typical pulled crystals of germanium is reckoned at 10^3–10^4 cm.$^{-2}$

Examples of the etch-pit arrays produced on germanium crystals which had been deformed in torsion were shown. After plastic torsional strains in the range 1°–10°/cm., the pit densities produced by CP4 etch were 10^{-6}–10^7 cm.$^{-2}$ These numbers are in agreement with the dislocation models for torsional deformation which involve *screw* dislocations.

The necessity for "calibrating" an etch was emphasized by reference to the etch known as "slow Superoxol". This etch produces pits of two sizes. On the specimens described above, it produced $\sim 10^6$ small pits/cm.^{2} before deformation. After deformation it revealed large pits on the slip traces whose number and location seemed identical with those produced by CP4, but the density of small pits was unchanged.

A second experiment was described in which etch-pits on either side of a slice were matched so that the direction of the dislocation line joining a pair of pits could be compared with their particular form. It was shown that the azimuth of the dislocation line may be accurately deduced from the pit shape, and by using this principle the directions of the dislocations lying in ⟨110⟩ traces on (111) transverse faces of pulled crystals were analysed.

Dr. J. W. Allen (Services Electronic Research Laboratories) described experiments on the plastic deformation of indium antimonide crystals in compression. The delay time for plastic flow was measured as a function of stress and temperature. Small specimens 2·8 × 0·9 × 0·6 mm. were compressed by means of a constant load, and the dislocation density as revealed by surface etching was measured after selected intervals. The end of the incubation period was defined as the time when the number of dislocations (originally about fifteen) had increased fourfold. Since the onset of slip was sharply defined, the incubation time, τ, was not very sensitive to this arbitrary choice of the factor of four.

A good representation of the results was found to be

$$\tau D T = \text{const. } F^{-1\cdot74} \quad . \quad . \quad . \quad . \quad (1)$$

where T is the absolute temperature, F the applied load, and D the activation energy for impurity diffusion. Its value was found by plotting log (τ . T) against T^{-1} for a constant load.

This functional relationship (1) was discussed in terms of a theory which involved the idea that the rate of production of dislocations depends upon the number and velocity of those present at that instant. The model was compared with Seitz's explanation of the incubation period which is in terms of the thermally activated dispersal of impurity atoms from Frank–Read dislocation sources.

Mr. R. Phillips (Associated Electrical Industries, Ltd.) described observations made by transmission electron microscopy. The technique developed by Hirsch for the examination of thin metallic films was adapted for the examination of specimens of germanium, silicon, and bismuth telluride. Specimens of germanium and silicon were prepared by first grinding to a thickness of about 100 μ. Mechanical polishing and etching in a 1% aqueous sodium hypochlorite solution were employed for final reductions. The field of view of the electron microscope at useful magnifications is 10–100 μ^2, so that the chance of finding a dislocation in a specimen obtained from a grown crystal of silicon or germanium, whose dislocation density is 10^3–10^4 cm.$^{-2}$, is very small. In fact, none was found in such specimens. However, some very beautiful pictures of the dislocations produced by deformation in a hot-hardness machine were obtained. Effort had been concentrated on germanium, particular attention being paid to the effect of the temperature of deformation on the pattern of dislocations produced. The dislocation density beneath hot-hardness impressions was $\sim 10^9$ cm.$^{-2}$, and under the extreme stress conditions there the dislocations were sufficiently mobile at 700° C. for appreciable polygonization to occur in as short a time as 30 sec.

Dr. J. W. Mitchell (University of Bristol) gave the final paper, a general discourse on the experimental observation of dislocations in inorganic crystals. He stressed the advantages of studying the physical properties of selected "model" substances with a view to gaining an insight into the behaviour of the materials of industrial importance which are often less tractable. Thus, transparent silver halide crystals provide a good medium for studying plastic deformation. The technique which has been developed for decorating dislocation lines with silver makes it possible to follow the dislocations right through a crystal.

This separation of silver along dislocation lines shows that electrons must have been trapped there; otherwise the silver ions could not have been discharged to form silver atoms. It was suggested, however, that the electrical effects of dislocations in semi-conductors may arise more from their "surface properties" than from their "line properties". Where a dislocation meets the surface of a crystal, there is a region of enhanced reactivity.

Several pictures of dislocation structures in both annealed and deformed silver halide crystals were shown, and attention

was drawn to the ease with which dislocations can be produced by thermal strain.

Prismatic dislocations produced by an embedded glass particle may be swept through volumes of silver bromide crystal some 150 μ long before they encounter, and become entangled with, another dislocation. This suggests strongly that these volumes are free from dislocations, and that the silver-decoration technique reveals all the dislocations present.

The high perfection characteristic of the pure silver halide has not been obtained in mixed crystals. It appears that dislocations arise here as a result of concentration gradients.

Discussion

In the general discussion which followed, Dr. C. A. HOGARTH (Royal Radar Establishment) described microprobing experiments designed to measure the fine-scale variation of electrical potential with distance in a crystal of germanium containing walls of parallel dislocations. The crystal was connected in a simple battery circuit and very careful measurements were made at intervals of 0·5 μ. In a *p*-type specimen, local regions of high conductivity coincided with the positions of the dislocation walls as revealed by etch-pits.

Mr. O. P. HARTREE (Associated Electrical Industries, Ltd.) described hardness measurements on germanium crystals in the temperature range 230°–700° C. The effects of time and temperature of loading on the apparent hardness value and also on the configuration of dislocations beneath the impression were examined.

Dr. MITCHELL made the point that whereas the direct observation of Frank–Read sources in silicon by W. C. Dash had confirmed this theoretical concept, there was a growing body of observational evidence that other mechanisms for the production of dislocations must exist.

The Chairman raised the question of the term " one-to-one correspondence " which had been used by various speakers in different ways. Dr. Bell had used the term to describe the situation where the number of etch-pits found at a small-angle boundary of known angle, or in a crystal bent to a known radius, was the same as the number of edge dislocations predicted by theory. Dr. Mitchell had used the term when each etch-pit marked the emergence of a line of precipitate.

In reply to questions, Dr. MITCHELL speculated on the general problem of etching. It seems probable that a good etch for revealing dislocations needs to contain a small concentration of a substance that is adsorbed on the specimen surface in such a way as to " poison " all the surface except the regions where the dislocation lines emerge. A scientific rather than a " cookery-book " approach to etching is badly needed.

Exhibition

In conjunction with the Symposium an exhibition was held in which most of the semi-conductor laboratories of the country were represented. It was arranged by Dr. W. Bardsley. Crystals of germanium and silicon, together with typical etch-pit photographs, were shown by several companies. There was a miniature Czochralski apparatus, but more exciting was the working demonstration of the floating-zone technique with electron-bombardment heating. This technique, developed and exhibited by the Services Electronic Research Laboratories, is proving attractive for the production of single crystals of the refractory metals.

A most impressive display of the intricate apparatus and technique used for the growth of compounds from the vapour phase was staged by Mr. A. Prior of the Royal Radar Establishment.

One aspect of " semi-conductor metallurgy " which did not come before the formal sessions of the Symposium was brought to our notice by Ferranti, Ltd. Their demonstration —also a working apparatus—showed how the metallurgical principles of controlled solidification have been applied in the production of improved alloy junctions on silicon.

OTHER NEWS

Fracture, Fatigue, and Failure

The British Society of Rheology is organizing a conference on " Fracture, Fatigue, and Failure " to be held at the University of Leeds on 8 and 9 January 1959. Further information can be obtained from the Hon. Secretary, 52 Tavistock Road, Edgware, Middlesex.

Pittsburgh Diffraction Conference

The Sixteenth Annual Diffraction Conference will be held at the Mellon Institute, Pittsburgh 13, Pa., on 5–7 November 1958.

Papers on the following subjects are invited: substructures in crystalline materials, intermetallic compounds, electron diffraction, neutron diffraction, instrumentation, semicrystalline and amorphous materials, metals, alloys, and diffuse scattering.

Titles of papers offered should be sent before 1 September to the Programme Chairman, P. K. Koh, Allegheny Ludlum Research and Development Laboratories, Alabama Avenue, Brackenridge, Pa. Abstracts of the papers should be submitted not later than 20 September.

APPOINTMENTS VACANT

CITY OF LEICESTER EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY AND COMMERCE

Applications are invited for the following posts in the School of Engineering, to commence 1 September 1958:

(1) Lecturer in Metallurgy to teach the subject to National Certificate and Degree levels.

(2) Assistant Lecturer (Grade B) to teach Machine Shop Engineering. Ability to assist with Automobile Engineering an added recommendation although not essential.

Salaries: Burnham Technical Scale—Lecturer: £1200 × £30 to £1350 per annum; Assistant Lecturer (Grade B): £650 × £25 to £1025—with Degree and training allowances and increments for approved teaching and/or industrial experience and War Service.

Forms of application, to be returned as soon as possible, and further particulars can be obtained from the Registrar, College of Technology and Commerce, Leicester.

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